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ECOLOGY IN AGRICULTURE.

DRIED GRASS CONCENTRATE IN THE TROPICS.

FURTHER STUDIES IN TROPICAL LAND TENURE.

BANANA DISEASES.

SOIL NUTRITION.

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ECOLOGY IN AGRICULTURE.*

THE significance of the science of ecology, which was described by its founder, E. Haeckel, as the study of the interrelationship between the organism and its habitat, received a wider appreciation by Elton, who considered that ecology, more than any other branch of science, is capable of rendering practical aid to laymen. Indeed, the agronomist, according to Keller, acts first of all as a practical ecologist, endeavouring to fit together the dynamics of an environment and of plant development as closely as possible in order to gain the fullest advantage from the plant. In Keller's opinion "ecology is a study of the peculiarities of forms, structure, chemical composition and the entire life of a plant in the closest possible relation and interaction with definite characteristic combinations of environmental conditions in their dialectic unity". It thus appears to be the science nearest to agriculture, linking physiology, anatomy and biochemistry with everyday practice, bringing the results of laboratory studies into the open, the field of man's action. Despite its recent origin, there has now been collected on the subject of ecology an extensive body of experimental evidence, much of which has not yet found way into practice.

Agronomists do not as a rule give due attention to the ecological aspects of soil preparation ; meanwhile, as stated by Lebedev (Lebedev, S. P. On the organization of ecological research in agricultural plants. *Sov. Bot.*, No. 6, 1937, pp. 42–55) any preparation of soil has a definite effect on the light, temperature, water and air environment of the soil, which in turn deeply affects the growth, development and general well-being of the plant. In connexion with the geographical variation of characters, plant breeders do not give enough consideration to the establishment of optimal conditions for each variety bred in a given locality, nor has due consideration been given to mutations arising in seeds under various conditions of storage. Soil scientists almost entirely disregard the vegetation as an expression of the chemical and physical properties of soil, which are of such importance in the reclamation of new land, cultivation of marshlands and grasslands, not to speak of their close association with the general well-being of the plants. In reporting the general climatic features of a locality, meteorologists almost entirely neglect the study of the micro-climate of the soil and the air layers immediately above the ground level, the environment in which the plant actually lives.

* *Herbage Reviews*, Vol. VI, No. 3, pp. 185-6, 1938

In this connexion, of rather general interest is the programme of ecological research with reference to development and yield of agricultural plants, drawn up by S. P. Lebedev and given below in a condensed form:

(1) The effect of light: optimal light conditions for plants and their varieties at different phases of their life; the efficacy of various methods of influencing the light environment; regulation of light conditions in ecologically different environments.

(2) The effect of temperature: optimal temperature for plants and their varieties at different phases of their life; the efficacy of various means of influencing the temperature of the micro-climate of the soil and the layer of air just above the ground; resistance of plants to low and high temperature throughout their life.

(3) The effect of moisture and rainfall; the optimal conditions for each variety; regulation of air moisture by means of various agronomical methods in ecologically different environments.

(4) The effect of overground air and soil air: the dynamics of gaseous exchange between the soil and the atmosphere; the structure of water-permeability of the soil; the composition of the soil air; the effect of various components of the air on the plant at various phases of its life; regulation of air environment of the soil by agronomical methods.

This list of course cannot claim to be exhaustive but, considering our meagre knowledge of these fundamental problems, the items may be regarded as deserving immediate attention. The isolated study of a factor, as V. H. Blackman showed, is not, however, sufficient, as the plant responds to the entire complex effect of interrelated factors. Moreover, these complex effects must be studied with the closest reference to plant development, as Lysenko showed that "ecologically" the plant varies with its advance towards reproduction. Again, Kostjucenko and Zarubailo and other investigators have shown that in any ecological study the conditions under which the plant completes its embryonic period (seed ripening) must not be neglected. Finally, in ecological studies it is very desirable to record the daily and seasonal dynamics of climatic factors as accurately as possible, as the plant responds not to a daily average of any particular factor, but to its daily variation and range. In particular, the temperature around the plants should, whenever possible, be thermographically recorded, or at least the daily maximum and minimum must be taken. In recording daylight it should be borne in mind that the intensity and quality and hence the effect of the daylight vary throughout the day, as shown by Razumov and others.

M. A. O.

MODERN TEA CULTURE.

In an article entitled "The Application of Science to Modern Tea Culture" published in the *Empire Journal of Experimental Agriculture*,* the author reviews the improvements brought to tea-cultivation through the medium of scientific research. Nitrogen manuring was first developed by Mann of the Indian Tea Association by means of locally made rape seed cake; subsequently other organic materials such as fish, sterilized animal meal and various kinds of cake and débris obtained from specially grown leguminous trees were used. Its bulk is often advanced as an additional asset of organic manure, but at Tocklai over 4 years an annual application of 5 tons of cattle manure equalling 60 lb. of nitrogen, has given an increase of only 765 lb. of tea per acre compared to the 1,580 lb. increase obtained during the same period with 60 lb. of nitrogen in the form of sulphate of ammonia, and over a period of 17 years no improvement in tea or soil has been attributable to bulk as against an absence of bulk in manures. In tea, slow acting manure is an inefficient manure. Repeated small doses of a soluble manure are of no greater efficacy than their total amount given annually in one application even when the latter is very large. In the acid soils of North-East India a soluble manure such as sulphate of ammonia broadcast in spring gives the same increase in yield whether it is left on the surface or lightly turned in. No depletion of organic matter of the soil through the use of sulphate of ammonia is to be feared, if the tea prunings are buried, as is customary, in the soil of the plantation. It has been conclusively shown that the yield and quality of tea can be maintained by the use of moderate applications of nitrogen only, and this discovery has made possible a reduction of 25 per cent. or more in the cost of manuring.

Cultivation.—Tillage merely provides a good seedbed for weeds. Hand weeding results in erosion. Selective weeding leaving only shallow rooted plants is most practicable. Under such conditions combined with suitable nitrogenous manuring the bushes grow rapidly and soon cover the soil, their roots come to the surface and suppress such weeds as are left.

Variety and Quality.—The next big development in tea culture is likely to be in the establishment of pure strains. At present there is little uniformity and vegetative propagation is still undeveloped, though research is active.

Pests and Diseases.—Satisfactory control measures have of recent years been established for all the more serious pests and diseases.

Manufacture.—The general process of manufacture has undergone little change except in improvements in machinery, but the realization of the ill effects of the uncontrolled development of micro-organisms in factories has contributed to the improvement of tea. The chemical constitution of the tannin found in tea is now known to differ from the tannic acid (digallic acid) of the British Pharmacopoeia, thus the detrimental physiological reactions of digallic acid can no longer be misrepresented as attributable to tea-drinking.

* Vol. VI, pp. 1-10.

DRIED GRASS CONCENTRATE IN THE TROPICS.

A Preliminary Investigation into the Utility of Artificial Grass Driers for Fodder Crops in Trinidad.

By D. D. Paterson.

I.—Grass Drying.

During the last two decades, a better realisation of the importance of pastures and fodder crops in the general economy of the farm has been achieved and new systems of management have been evolved. In fact, the improvement of the nutritional output of grassland has become an important part of most agricultural research programmes. The discovery of the high nutritional value of young grass by Woodman and his colleagues at Cambridge (1) has given a practical impetus to this research, and there are available to-day several different types of grass drying machine which are capable of transforming young herbage into a dry meal or cake which can be stored indefinitely and used as a balanced concentrate foodstuff in livestock rations. Properly manufactured, this dried grass concentrate should have a composition of approximately 8-10 per cent. moisture, 15-18 per cent. crude protein, 60-70 per cent. starch equivalent and some 75 per cent. digestibility (2). The quality of the concentrate is determined by the chemical composition of the fresh herbage fed to the drier, and to ensure a first grade final product, it is essential to cut the herbage before its nutritive quality begins to fall off with increasing maturity. With English pasturage, this implies harvesting the grass every 3-4 weeks during the Spring flush, and every 5-6 weeks in the summer when growth is slower (3). It has been shown that, provided the herbage is cut at a young enough stage of development, the composition and nutritive value of the final product is practically independent of the botanical composition of the sward. The loss of nutritive elements during the drying process is negligible, so that the whole of the original quality of the young grass, including the protein, mineral, carotene, and vitamin contents, is retained (2). Drying therefore is a much more efficient method of preserving forage than either haymaking or ensilage, in which the average loss of the nutritive elements during manufacture has been estimated at 35 per cent. and 8 per cent. respectively (3). In consequence, in England, the artificial drying of young grass is now recognised as a practical method of herbage conservation, equally adaptable to the needs of the private farmer or to capitalistic enterprise whose ultimate objective is the sale of the dried grass product. This type of grass drying must not be confused with a somewhat similar one not uncommon in the United States of America, whereby hay and forage crops are machine dried. In this latter case, it is the mature or semi-mature crop that is artificially dried, in order to avoid the risks of haymaking by natural means. The final product is merely good quality roughage, and does not purport to be a concentrate foodstuff such as is obtained by the dried grass technique.

During the last three years, the operation of various driers at different centres in the United Kingdom has demonstrated that to be successful the process requires skilled and careful supervision. The average cost of making a ton of dried grass in 1936 was £5 17*s.* 6*d.* as compared with a retail sale price of from £8 to £10 for the first grade product. The process is only economically sound provided the dried grass ranks as a balanced concentrate which cannot happen unless the herbage is harvested at the correct condition as regards leafiness, maturity and internal and external moisture content. In practice, this may be difficult to effect even under skilled management and consequently the final product tends to vary widely in quality. It has therefore become necessary to grade the dried grass according to quality, the recognised grades (4) being as follows:

	Crude Protein, per cent. of Dry Matter.
Grade I	....17 per cent. or more.
,, II	....14-17 per cent.
,, III	....12-14 per cent.
Super hay	....Less than 12 per cent.

At existing costs of production, only the first two grades leave a reasonable margin of profit, and even this is dependent on an annual production of sufficient tonnage of dried grass to offset depreciation and interest on a relatively high capital outlay. A small drying plant to-day costs about £500 to purchase, and this capital outlay would only be justified provided the plant is worked a considerable number of hours each year. Finally, the concentrate replacement value of the dried grass cake has not been accurately determined. For example, it has been shown that while dried grass may be fed liberally to cattle and sheep, there is a limit to the amount it is advisable to include in the rations of pigs and horses (4). As with most new processes, the initial difficulties in the commercial production of dried grass are therefore not far to seek, yet it appears certain that the practice is one that will gain steadily in popularity and will ultimately become a standard farm operation of definite economic importance. It is therefore interesting to consider whether there is likely to be the same scope for the use of artificial grass driers in the tropics.

II.—Local Conditions.

In Trinidad, the insular tropical climate with a heavy and fairly evenly distributed annual rainfall makes pasturage and fodder production or preservation a very different problem from what it is in the temperate zone. Green roughage, either from natural herbage or from cultivated perennial grasses, is available for some ten months

in the year, and there is no need to preserve roughage even in the short dry season, as a plentiful supply of coarse fodder is available from the sugar cane fields which are harvested at that time. The yield of herbage from a cultivated perennial fodder grass under good management is very high, 40 to 50 tons per acre per annum being an average return and over 100 tons per acre a definite possibility on fertile land. On the soilage system of livestock management, a relatively small acreage of a cultivated fodder crop will provide a maintenance ration for a considerable head of stock. For example at 60 lb. per day per head, (5) four to eight oxen per acre could be maintained. The nutritive quality of both the natural and cultivated herbage is relatively low, and even close cropped Savannah Grass pastures cannot compare in quality with pasturage in England, though the gross yield may be greatly superior. Using some of the better crop grasses in Trinidad, it was decided to investigate the possibility of obtaining young herbage of a quality that could be reckoned as suitable for the production of dried grass concentrate.

III.—The Experiment.

Six plots, 12′ × 15′ in size, exclusive of the non-experimental borders, of each of the following four grasses were established on the farm of the Imperial College.

Para Grass (*Panicum barbinode* Trin.).
Elephant Grass (*Pennisetum purpureum* Schumach.)
Elephant Grass (*Pennisetum purpureum* var. Uganda.)
Savannah Grass (*Axonopus compressus* Beauv.)

The first three are known to be good perennial cultivated fodder crops, and the last is the only pasture grass of any practical significance grown in Trinidad to-day. After an establishment period of nine months, the plots were considered to be in sufficiently good condition to provide experimental data, and the experiment started on 27th July, 1937, and was allowed to continue for the ensuing six months. Of the six plots of each grass, two plots were harvested at two week intervals, two at four and two at six week intervals—Series 2, 4 and 6 respectively. To ensure a leafy type of herbage, the three perennial fodder grasses were cut at 9 inches to 12 inches above ground level, a practice which has already been shown to have some advantage in improving the quality (5). The Savannah Grass was mown with a hand lawn mower, set to cut about 1 inch high. The selection of the three harvesting series is based on the fact that cutting oftener than every two weeks is liable to kill off the plant and that wider intervals than six weeks are bound to yield produce of too low a quality for dried grass production. At each harvest, duplicate samples of the herbage of each variety and each series were procured as already described (6) and analysed chemically for dry matter and protein content. The resultant data, representing the mean values over a period of three months, are summarised in Table I.

IV.—Yields.

While the experiment was not designed to provide an elaborate statistical comparison of the yields of the different treatments, the trend of the mean values is sufficiently marked to indicate the following features. The average yield for all treatments works out at 40 tons per acre per annum, a satisfactory figure considering that the produce is all in the nature of leafy herbage with a low fibre percentage. For each variety without exception, the longer the interval between harvests, the greater does the yield tend to be in the proportion 100 : 128 : 158 for the two-, four- and six-week harvesting rotations respectively. The Savannah Grass is decidedly the poorest yielder, at the rate of only 20 tons per acre per annum, while the Para Grass and Uganda Elephant Grass are superior to the ordinary Elephant Grass.

Table I.

Mean Yields and Composition of Herbage for the period July 27th to October 18th, 1937.

		Para Grass.	Elephant Grass.	Elephant Grass—Uganda Variety.	Savannah Grass.	*Series Mean.*
Yield of Herbage (lb. per plot) (12′ × 15′)	Series 2 ...	97.2	62.2	86.5	34.2	**70.0**
	Series 4 ...	109.2	98.2	110.5	40.5	**89.6**
	Series 6 ...	136.0	113.7	132.0	59.0	**110.2**
	Variety Mean	**114.1**	**91.4**	**109.7**	**44.6**	...
Dry Matter (per cent.)	Series 2 ...	16.84	13.28	12.15	27.73	**17.50**
	Series 4 ...	18.88	13.69	12.84	28.06	**18.37**
	Series 6 ...	22.55	13.28	14.76	23.93	**18.63**
	Variety Mean	**19.42**	**13.42**	**13.25**	**26.57**	...
Crude Protein (Per cent. of Dry Matter)	Series 2 ...	13.10	11.71	11.85	12.41	**12.27**
	Series 4 ...	10.42	9.79	9.20	10.95	**10.09**
	Series 6 ...	7.37	7.52	7.52	9.55	**7.99**
	Variety Mean	**10.30**	**9.67**	**9.52**	**10.97**	...

V.—Dry Matter.

In the manufacture of dried grass, the water content of the fresh herbage is a feature of considerable economic importance and is responsible for a new term, namely the "water-ratio". In grass drying technology, the water-ratio is the number of units of water that has to be evaporated to produce one unit by weight of dried grass from a given sample of herbage. The importance of the water content of the herbage is effectively illustrated by the following examples. In making one ton of oven-dry grass, a drop from 90 per cent. to 80 per cent. in the moisture in the herbage reduces the water-ratio from 9 to 4, so that the number of tons of water that has to be evaporated is reduced to less than half the original figure. Similarly, a rise in the amount of water in the herbage from 75 per cent. to 80 per cent. leads to an increase in the water-ratio from 3 to 4 (2). The output of dried grass per hour from any machine is approximately in inverse proportion to the water-ratio of the herbage, so that this 5 per cent. increase in the water content reduces the production of dried grass to $\frac{3}{4}$ of its former value, entailing a very considerable addition to the operating costs. This point has been stressed, as at current rates, only herbage with a good dry matter content can be economically converted into dried grass. Raw material with over 85 per cent. water can be ruled out on this count alone. It should be noted further that wilting of the grass, to reduce the moisture percentage before it goes through the machine, is not a practice that can be safely recommended, as it introduces additional difficulties in the operation of the drying plant.

Examination of the dry matter percentages for the four species of grass shows that the two varieties of Elephant Grass are both too succulent to be suitable for dried grass production. The Para Grass is fairly satisfactory and the Savannah Grass, especially the younger herbage is very good in dry matter content.

If the dry matter percentages are used to provide an estimate of the yield of dry matter as distinct from that of green herbage, the potential yield of the varieties works out proportionately:

Savannah Grass	100
Elephant Grass	103
Elephant Grass, Uganda var.	123
Para Grass	188

The Savannah Grass has come up in the yield scale being little inferior to either variety of Elephant Grass, and the Para Grass is greatly superior to any of the other three species.

VI.—Crude Protein.

It has already been stated that successful dried grass manufacture depends on a final product of high quality, containing at least 15 per cent. crude protein. The best protein figure recorded in Table I is 13.1 per cent. for young Para Grass herbage, equivalent to 11.79 per cent. crude protein in dried grass with 10 per cent. moisture. None of the grasses at any of the harvesting rotations gives produce of the required nutritive quality, though all show considerable improvement over the same species used as a soilage crop when the crude protein in dry matter is generally below 7 per cent. (5). As would be expected, in each species without exception, produce from Series 6 is poorest.

VII.—Harvesting Rotation.

Careful observations were taken of the effect of the length of interval between harvests on the health and vigour of the plants. In the Savannah Grass, all three series remained healthy, and contrary to expectation, the sward on the plots cut every two weeks was both thicker and better able to resist a mild infection of mole crickets than the other two series. With both types of Elephant Grass, cutting every two weeks ultimately killed a number of the stools and the six-week intervals gave rise to a healthier growth than the monthly harvests. The Para Grass survived satisfactorily under all three types of rotation, but the yield from the plots cut fortnightly was both poor and showed a tendency to decline towards the end of the experiment. With good cultivation, Para Grass cut high appears able to withstand harvesting every four weeks.

VIII.—Discussion and Conclusions.

None of the grasses tested in this experiment is considered to be suitable for the production of dried grass concentrate, chiefly because the herbage, even when harvested every two weeks, is of too low nutritive value to make artificial drying an economic project. In order to form an estimate of the maximum protein content likely to be found in local pasturage, a further sample of very young Savannah Grass was analysed. This consisted entirely of young freshly sprouted foliage of less than one week's maturity, and its quality may be assumed to approach the richest obtainable from this grass under local conditions of soil and climate. The chemical analysis gave the following results:—

	Dry Matter, per cent.	Crude Protein, per cent. of dry matter.
Young Savannah Grass	22.60	13.88
English Pasture (1) (1 week's maturity)	19.5 to 31.0	21.20 to 27.92

The crude protein content is a little better than that obtained from fortnightly cuts (Table I), but it is still markedly lower than that of English pasturage mown at approximately the same stage of development. There are other tropical grasses which are known to be superior to Savannah Grass in nutritive quality. For example, analysis of very young Bahama Grass (*Cynodon dactylon*),

also from the College savannah, gave 29.60 per cent. of dry matter and 20.31 per cent. of crude protein in dry matter, a very much better result than that obtained from the corresponding sample of Savannah Grass. On a field scale, it would be impracticable to collect herbage at such a young stage of growth, and in any case, the yields would be too low to permit of such a project on economic grounds. Furthermore, the high quality of young grass is not considered to be so dependent on the composition of the sward as on the maturity of the herbage when it is cut. It has already been shown that under tropical conditions there is a tendency, with increasing maturity, for the protein percentage to crop much more rapidly than in a temperate climate (7). For example, fresh sprouted shoots of Elephant Grass contain up to 22.5 per cent. of crude protein in the dry matter (7), but when they are a week old, the protein content will almost certainly be below 12 per cent. It would appear that the main factor responsible for the relatively low quality of young tropical grass and its apparent unsuitability for conversion to a dried grass concentrate, is the excessively rapid reduction in nutrient quality with increasing maturity. The inferiority in the chemical composition of most tropical fodder species relative to English herbage must also be regarded as a contributory factor.

Of the four grasses included in the experiment, Savannah Grass is the most promising as it stands up to frequent cutting, has a high dry matter percentage, is of fair nutritive quality, and can be harvested by the available types of mowing machine for dealing with short herbage. It yielded at a rate exceeding 5 tons dry matter per acre per annum which is about double what is normally obtained from English pasturage (2). Growth continues for over three-quarters of the year, and the rate of growth is fairly steady, varying a little with the rainfall incidence but showing no marked Spring flush. This should simplify the management of areas kept for dried grass production, although, in prolonged spells, there might be occasional difficulty in obtaining herbage that was sufficiently surface dry to be suitable for putting through the machine.

The experimental data show that it is possible to obtain a good yield of herbage which could be converted into dried grass of the grade known as super-hay (less than 12 per cent. crude protein). This would hardly rank as a concentrate, but would be greatly superior to the average quality of green or preserved roughage at present fed to stock in Trinidad. It would only become a practical proposition provided the cost of harvesting and drying could be reduced considerably below the average figures quoted for dried grass manufacture in England—£5 to £6 per ton of dry produce. Some saving should occur on account of the cheaper labour generally available in the tropics, and also with future improvements in technique and design of drying machinery. There is also the alternative of preserving the herbage in the form of silage instead of as dried grass. The losses in storage in this form would be a little greater, but with skilled supervision, the silage should otherwise retain most of the valuable nutritive elements—carotene, protein, minerals—of the green material. With a protein-rich herbage, the formation of lactic acid in the silo may be insufficient to guarantee proper fermentation of the produce (4). This difficulty may be overcome by using the A.I.V. technique in which mineral acids are added during the filling of the silo, or by the addition of molasses to the green material. In Trinidad, the latter method would add very little to the cost of manufacture. In any case, the total expenditure should be much less than in the case of dried grass. The utility of the final product would admittedly be more limited, as silage is essentially a commodity intended for home consumption, whereas dried grass as a commercial product might be sold in the local markets or even exported. However, on economic considerations, it is suggested that as a method of preserving tropical herbage, ensilage is preferable at present to the use of artificial driers.

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FURTHER STUDIES IN TROPICAL LAND TENURE.

By H. M. Leake.

(*Continued from Tropical Agriculture*, Vol. XV, No. 11, p. 245.)

V.—WEST AFRICA.

The Gold Coast.

The Gold Coast is a composite group of territories made up of the Gold Coast Colony of about 24,000 sq. miles with a population density of some 72 per sq. mile; Ashanti, also of some 24,000 sq. miles with, however, a population density of about 28; the Northern Territories of some 30,500 sq. miles with a population density of about 26 and the mandated territory of Togoland with an area of some 43,000 sq. miles and a population density of about 23. Physiographically the Gold Coast is divided into two zones, a coastal zone, embracing the Colony and Ashanti and the coastal belt of Togoland with a wet climate where man has to struggle against the vigorous growth of a tropical rain forest, and a dry hinterland embracing the Northern Territories and the remainder of Togoland.

From the land tenure point of view the outstanding fact of importance is that, both in the Colony and Ashanti, there is no Crown Land in the sense accepted in East Africa and elsewhere; land, that is, which is undeveloped and lapses to the Crown because there exists no claimant to the title. In these territories all land is in the possession of some owner and Crown Land is limited to that which has been acquired. In the Northern Territories, on the other hand, under the Northern Territories Lands and Native Rights Ordinance (1 of 1927), all lands were declared to be public lands with, however, recognition of proved existing titles. The history of the origin of these divergent systems has been adequately described in the earlier series of articles. The policy as there described has undergone no alteration. In both cases a plantation system of agricultural production has not developed, in the central belt because of the land system, in the hinterland because of climatic unsuitability which has not proved attractive to alien capital, and of a policy which has not encouraged development along such lines. The united territories, thus, offer an example of a peasant system. The population, from the agricultural aspect, is not dense, that of the Colony being inflated by the urban population of the ports, and there is little or no real pressure on the land. Native custom has, therefore time to undergo a gradual evolution fostered by a policy of devolution. It is the universality of this peasant system and the fact that the economy of the Gold Coast is dominated by cacao that give direction to the problems of the territories.

Until 1930, cacao formed roughly between 70 and 80 per cent. of the value of total domestic exports or, if lumber, minerals and diamonds be excluded, between 92 and 98 per cent. Though this dominance has decreased in recent years, the change is due less to an altered status of production than to change in the relative value of cacao and gold. Cacao is the product of a tree which, as trees go, has a relatively short life. Field yields begin to fall off after some 25 years. Young as the industry is in the Gold Coast, the crops planted during the period of rapid expansion early in the present century have already reached that age and, unless experience elsewhere prove a fallacious guide, will give a diminishing yield in future. Unless this decrease is counterbalanced by the opening up of new areas, production at its prevent level is likely to decline. That is a prospect which will react on the prosperity of the Gold Coast as a whole; but more important, from the tenure point of view, is the reaction on the individual owner of a holding. He will be faced with the prospect, through the ever decreasing value of his holding, of having ultimately to open up a new one elsewhere. That process has already begun and, apart from the personal aspect of the farmer, raises important communal problems such as the destruction of high forest which are already calculated to have been reduced during the last 40 years by 11,000 sq. miles from 25,000 to 14,000 sq. miles, though other agencies than the spread of cacao may have played a major part in this reduction. So far as the urge imparted by the deterioration of cacao holdings through age has played a minor part but one which is likely to become more and more important. The alternative, and desirable, course is to be found in the maintenance of the productivity of the present area on a permanent basis. This means, however, greater skill in management and the gradual replacement of ageing trees. It is an alternative which raises the problem, not met here for the first time, of how such technical skill is to be developed and universalized among an independent peasantry.

The product of the cacao tree is the cacao bean and the process by which it is prepared for the market is one which involves fermentation, and all processes of this nature require a good deal of technical skill if the uniform graded product which alone will find a ready market under present conditions, is to result. How far such technical skill is possessed by the Gold Coast peasantry at the present time is shown by the prices realized in the markets. On the average of the years 1930-34 cacao from all sources received a premium to that from Accra; Brazil 16 per cent., Trinidad 60 per cent., Ceylon 91 per cent., Ecuador 145 per cent. and Venezuela 160 per cent. This

premium is partly due to varietal differences. Though no country grows a single type, those receiving a high premium carry a dominant proportion of plants of the Criollo type while the dominant type in the Gold Coast is the inferior, if more robust, Amelonado type. The possibility must not be overlooked of the substitution of the Criollo, for the Amelonado type. Such a step however not only raises difficult practical problems when it is a peasantry that is involved, and would necessarily be a lengthy process but might fail in its objective of raising the value of the Gold Coast product. Premia are paid for a higher quality in limited amount and the result of such a step might very well be the reduction of the value of all cacao to the lower level. But if difference of type is a contributing cause, an even more important one is the manner in which the preparatory process is carried out. That process, as has been said, involves fermentation requiring considerable skill, skill which shows itself as ability to control temperature in the heap. One prior condition is a heap large enough to maintain the desired temperature. Since, however, the average peasant handles only four acres, and this area is frequently subdivided, an adequate supply is only obtainable by unduly prolonging the intervals between pickings. From the *Scylla* of a heap too small for adequate control of conditions, the peasant escapes only to fall into the *Charybdis* of a heap containing both over, and under, ripe beans, the one as incapable of giving the desired product as the other.

The cacao industry of the Gold Coast, thus, illustrates perhaps better than any other the difficulties inherent in production for export under a peasant system of tenure, for it is a crop in which both the cultivation and the preparation of the product involve thought for the future and technical skill of no mean order. Two of the difficulties have been noted above, but there are others. The individual units are so small and scattered that direct sale to the merchant and exporter is impossible and disposal is to up-country agents. The peasant is not encouraged to prepare a quality superior to the average for, under these conditions, his contribution cannot be kept apart and will be bulked with the rest. Better quality as the result of individual action will not receive its due premium.

The problem of stimulating the production of improved quality has exercised the mind of the Agricultural Department for some years. A system of voluntary inspection with grant of a certificate proved ineffective for various reasons, not the least of which lay in the practical difficulties in the way of sampling gross lots, the different bags of which might contain very different qualities, and experience showed that the certified grade frequently exceeded the grade as determined on the American and European markets. After much hesitation, resort has been made to a co-operative system organized under the Co-operative Societies Ordinance (4 of 1931) The movement has made promising strides. From 31 societies with a membership of 964 and a paid up capital of £1,329 in 1929-30 it has expanded to 427 societies with a membership of 10,768 and a paid up capital of £25,832 in 1936-37. Of these 397 are concerned with cacao and 15 with bananas. This development led to the deputation of C. Y. Shephard to the Gold Coast, whose report * forms an important document in as much as it deals primarily with marketing societies whereas elsewhere it is credit societies which dominate in the Colonies. The organization of Co-operative Producers Societies enables inspection to be conducted up-country and, in consequence, the bulking of individual lots by grade and the sale of this bulk at a premium which, as it accrues to the producer, provides the stimulus to aim at quality. That Ordinance proved too restrictive for the developing movement and was repealed and replaced by the Co-operative Societies Ordinance (15 of 1937) which made provision for the combination of the primary societies into a federation and also enabled them to enter into contracts for the supply of produce and for the delivery of produce to buyers. The potentialities of the establishment of fermentaries, after the model of those in Trinidad under the same principle of co-operation, is being explored. At best, the movement is likely to be slow and a long time must elapse before the standard of the crop as a whole could be raised by this method. The problem was, therefore, attacked from another direction by the passage of the Cocoa Industry Regulation Ordinance (14 of 1934), an Ordinance following the lines of similar Ordinances passed in other Colonies by making inspection before export compulsory. This Ordinance, too, has been repealed and replaced by the Cocoa Industry Regulation Ordinance (14 of 1937) differing from the previous Ordinance in defining grades instead of merely prohibiting the export of produce below a certain minimum standard.

Meanwhile the slump in cacao had emphasized the precariousness of a country which is dependent on a single product and efforts have been made to widen the basis of production. The Coconut Industry Ordinance (18 of 1934) followed the same lines as the earlier Cocoa Industry Regulation Ordinance in defining a minimum standard for export with an inspectorate under the control of the Director of Agriculture. In a further effort to add a banana industry, for which a shipping service equipped with cold storage is essential, Government itself entered into a contract for the supply of a minimum number of bunches to ensure the service and, to enable it to fulfil the contract, secured the passage of the Banana (Control of Export) Ordinance (24 of 1935) which permits export only under licence. The cultivation of bananas is again fostered through societies organized, as in the case of cacao, under the Co-operative Societies Ordinance.

* The Economy of Peasant Agric. in the Gold Coast, 1936.

Nigeria.

Nigeria has a special interest as a policy having a clearly defined objective directed towards a definite goal replaced the earlier haphazard systems found elsewhere. This is the policy of devoluted control and its application is found in its purest form in Northern Nigeria where, owing to the late date of the incorporation of these territories in the British Empire, lay a field untrammeled by earlier policies. Though the Ordinances by which this policy is implemented have been extended to the whole of Nigeria, earlier conceptions have limited the freedom of its application in the rest of the colony. This policy of devolution intimately concerns the land and tenure is, as far as is consistently possible, in accord with native custom. Provision has to be made for revenue, the chief source of which is necessarily, in a country where production is predominantly agricultural and minerals play only a secondary rôle, the land and its produce. The tax which constitutes this revenue, is based less on the land than on the produce derived from it and is of the nature of a graduated income tax, and its assessment is one of the more important functions of the administrative staff. The method of assessment differs in the three sections of the territory. In the Northern Province the area of each village is ascertained, the average market value of the produce including the amount and value of special irrigated crops is determined and the village livestock counted. To the assessment so determined is added an equitable assessment of the production of the non-agricultural section of the community, the determination being made with the assistance of the headmen. The total so arrived at is assessed against the village and the apportionment among the individual members of the village left to the headmen and elders. In the Southern Province the average gross income of the peasant farmers and the number of adult males are determined and a tax imposed at the rate of 2½ per cent. The total assessment arrived at in this manner is notified to the village council for apportionment. Non-agricultural taxes are imposed on the basis of a determination of the income of typical members of the various trades, special rates are fixed and the assessment apportioned among individuals or groups. In the Cameroons the total wealth of the unit is determined, a lump assessment of 2½ per cent. imposed and this is apportioned by the headmen and elders. The rate of 2½ per cent. is a standard and may be varied; it has actually been reduced during the recent depression. This system of taxation arises out of the system of tenure which need not be described here as it has been depicted earlier and no later modifications have been introduced. It need only be said that it results in a typical peasant system in all its purity. There arises, therefore, the question as to how far the system has succeeded in developing the agricultural wealth of the territory in the interests of the native peoples.

Nigeria covers an extensive tract of country and, including a portion of the Cameroons, which is a British Mandate, occupies 372,674 square miles with a population of nearly 20 million, giving a density of 54 per square mile. This population is, however, unevenly distributed. The territory is divided into three administrative areas; the Colony proper, a small area of 1,357 square miles, consisting of Lagos and its environment with a population of some 368,500 giving the high density of 266 per square mile. Being largely urban it has no further interest in the present connection. The Protectorate of Southern Nigeria with the Cameroons has an area of 89,515 square miles and a population of some 8,250,000 giving a density of 92 per square mile. Northern Nigeria has an area of 281,703 square miles and a population of some 11,500,000 giving a density of 41 per square mile. The Cameroons have the lowest density, namely 16.4 per square mile. Physiographically the territory consists of a swampy coastal belt within which is a low-lying tract and, still further, a drier hinterland rising to a considerable elevation and gradually passing into the desert area of the Sahara. The division between the first two of these and the last corresponds roughly with the division between the Southern and Northern territories. These differences of population and climate materially affect the agricultural problems. Southern Nigeria is the home of the oil palm the products of which, oil and kernels, form the major export of the territory while cacao has been established over a considerable area. In fact, production for export is here carried on at the expense of maintenance production and necessitates purchase of food by much of the population.* In Northern Nigeria the main exports are groundnuts and cotton, both annuals and the latter of a type distinct from that grown in Southern Nigeria.

The problems which this system of peasant cultivation raised, were many and varied both owing to the nature of the different crops ranging from the oil palm, a semi-wild permanent growth and cacao, also a permanent crop, to cotton and groundnuts, to the need for providing the basic food requirements of the peoples and to the practice, particularly in Northern Nigeria, of shifting cultivation. That some regulation would be required was early recognized and an Agriculture Ordinance (55 of 1916) was passed which remained in force until it was repealed and replaced by a further Ordinance bearing the same title (4 of 1926). This is a comprehensive Ordinance covering practically the whole field of control including that usually dealt with in other Colonies by special Ordinance, the control of plant importation. Under it the Governor is empowered to make regulations for the control of sowing, collecting and ginning of cotton as well as of the kind of cotton to be grown, for the maintenance and improvement of the quality of cotton and for the inspection and grading of cotton and other

* Colonial Reports, Annual, 1528 (1930).

agricultural produce intended for export. Powers were also taken under it to appoint inspectors and advisory committees and to impose fees. The comprehensive nature of this Ordinance has permitted practically all the control found to be necessary to be imposed by Regulation. The agency entrusted with this control, acting in association with the Advisory Committees, is the Agricultural Department.

Oil Palm Products.—The oil palm is indigenous to West Africa which had, formerly, a monopoly of the trade in which Nigeria held the lion's share. It is, as already stated, wild or semi-wild so that it is hardly correct to speak of a crop in this connection. The major problem arises through the fact that the pericarp, from which one of the two oils yielded by the palm is secured, rapidly perishes with a loss of quality in the oil through the development of free fatty acids. Immediate and somewhat skilled treatment is required if the highest quality is to result. The problem of securing quality under the conditions presented by small peasant units has assumed added importance with the development of a plantation industry in the East capable of turning out a standard product and, in consequence of not only securing a premium but ousting the cruder African product in times of depression. Here, therefore, is the problem of a land system involving a peasantry in its most intense form.

Though the area occupied by the oil palm has probably been extended well beyond its natural range, the majority of the growth is volunteer; where the fruit has fallen there it has germinated and established a plant. There is no cultivation and the tree density is such that a strong growth is rarely possible. It is estimated that the self-sown tree takes some 30 years to come into bearing whereas the planted and carefully cultivated tree will begin to bear in four years and reach its maximum production in ten years. A cultural change is thus indicated and is being fostered by the Cultivated Oil Palm Ordinance (17 of 1935). Under this Ordinance oil proved to the satisfaction of the Director of Agriculture to be derived from such cultivated palms is exempted from export duty. There are obvious difficulties in the administration of such an Ordinance but an attempt at simplification is made by Regulation (24 of 1935) which is designed to foster the registration of societies and thus to aggregate the units.

The preparatory processes offer a double problem roughly indicated by the words quantity and quality. The former concerns the efficiency of extraction and, under the conditions which debar organization on a factory scale, is being met by the organization by the Agricultural Department of a supply of small imported presses on the hire purchase principle. Quality, which depends on immediate handling of the fruit to check fermentation, is sought in a series of Regulations, of which the latest is Regulation 12 of 1936, controlling and defining the quality grades permissible for export. These Regulations are administered by the Director of Agriculture with the assistance of an Advisory Committee composed of the Director as Chairman with representatives of the producers and exporters and two nominated members of the Lagos Chamber of Commerce. It is an indirect method, not controlling the actual process of preparation but placing a premium on well-prepared produce.

Cacao.—With the objective of securing higher quality, the control exercised in the case of oil palm products is, to a large extent, applied to cacao, the products of both crops being included in the same Regulations. The stimulus to better preparation is imparted through a premium on better quality. Nigeria has so far been free from the disease, *Marasmius* (Witchbroom), which is causing so much damage in Trinidad and other cacao producing areas of America and, to maintain that immunity, a control of cacao imports has been instituted by Regulation (27 of 1930).

Cotton.—The difficulties which are inherent in the problem of maintaining quality in cotton owing to its annual nature, its capacity for cross-fertilization, its susceptibility to pests and to the need for ginning the crop subsequent to harvest, have been sufficiently indicated and repetition here is unnecessary. Special measures have to be taken in all cotton growing countries, but, in Nigeria, there is the added complication, that two distinct classes of cotton are grown, the indigenous Ishan cotton of the Southern, and cotton of the American type in the Northern Territories. This peculiar position of cotton has been recognized in that the basic Agriculture Ordinance specifically mentions cotton and details various methods for its control while leaving other produce and crops for later specification in subsidiary Regulations. Among the more important Regulations is a Regulation which defines areas in which the American type only may be grown and lays down comprehensive marketing and grading rules (47 of 1926); a Regulation which defines a close season for *Hibiscus*, the alternative host for the bollworm (116 of 1925) and a Regulation which lays down marketing and export rules and establishes an Advisory Committee on the lines adopted for oil palm products (43 of 1937). The Agriculture Ordinance itself was amended (Agriculture (Amendment) Ordinance 24 of 1935) to include especially the control of the seed supply by a system of licensing buyers and sellers.

Other Crops.—Among the established crops a similar control has been established in the case of groundnuts (Regulation 37 of 1936). This Regulation laid down a standard of 2 per cent. foreign matter and authorized an inspection fee of 3d. per ton exported. But efforts have not been limited to such crops and attempts are being made to extend the range of agricultural produce exported. Control is here being established prior to the development of any serious trade in the product in the wise view that it is better to establish a

standard and to secure a reputation for quality than to overcome a reputation for low quality. The two products to which this principle is being applied are pineapples (3 of 1932) and oranges (20 of 1935). Under these Regulations inspection and standardization of the method of packing are enforced.

There remains for consideration one further aspect which has special reference to Northern Nigeria. Here, as has been stated, land is abundant, cultivation of the poorest, and to a large extent, shifting. Climatically, too, the territory is better suited to a standard system of agriculture with short season crops than to the perennial crops of the moist tropics. The first essential, therefore, is to build up a system of farming which, by maintaining the fertility of the land, will lead to a settled population. That is a revolution in practice which must be slow but is gradually being brought about by the efforts of the Agricultural Department. The devising of rotational systems and education in the practice of using cattle in a balanced system of mixed farming are obvious preliminary steps but too far from the present subject to be discussed here. The methods adopted for introducing such practices among the peasantry is, however, pertinent. Such a system implies a certain basic expenditure of capital on stock and implements and this is accomplished by means of loans advanced through the Native Administration and repayable in four years. For the purpose of establishing an average mixed farming unit a loan of some £8 to £10 is calculated to be necessary. This system appears to work well with little trouble in obtaining recovery for, in 1936, of the 1,052 loans made, 150 had been repaid in full and, of the outstanding loans, 573 were less than £6, 243 between £6 and £8; 68 between £8 and £10 and only 18 over £10.* The financing of the system is, however, one well adapted to co-operative effort under the Co-operative Societies Ordinance (39 of 1935) which has organized the sale of 1,379 tons of cacao, being the produce of 30 societies.

* Department Agriculture, Ann. Report, 1936.

Sierra Leone and The Gambia.

These two minor Colonies occupy respectively 28,000 sq. miles with a population of approximately 1,750,000 (density 63 per square mile) and 4,068 square miles, with a population of approximately 200,000 (density 49 per square mile). The export trade is small, in the former composed mainly of oil palm products and, in the latter, to the extent of some 96 per cent. of the total of groundnuts. No new developments have taken place with regard to tenure though, in Sierra Leone, a Summary Ejectment Ordinance (41 of 1932) has been passed to deal with the casual settlement on tribal land, and little has been done to stimulate export of agricultural produce. The stage of development, in fact, is such that Government is still actively concerned in one of its primary functions, which aims at ensuring the food supply of the peoples. In Sierra Leone, measures to this end were taken under the Foodstuffs (Control and Prevention of Exploitation) Ordinance (14 of 1932). The Native Produce Ordinance (16 of 1928) itself is largely directed to this end and Rules under it were issued in 1936 controlling the conditions under which rice might be stored. In the same year marketing of rice was organized co-operatively and an officially controlled rice mill erected. The only direct stimulus to export is found in Sierra Leone where the potentialities of building up an export trade in fruit are being explored and where control is imposed under the Fruit Export Ordinance (24 of 1933) based on the same principles as those passed in Nigeria for pineapples and oranges.

COPPER DEFICIENCY IN CULTIVATED SOILS.

Reclamation disease has been known in parts of Northern Europe for some time. It was first recognised as a disease and named by Elema, the name being derived from its frequent occurrence on sandy heaths and moorland soil recently reclaimed. These soils are rich in humus and strongly acid, but it is also found in peaty clay soils; in Denmark, it has occurred in *Calluna* heath soils when brought into cultivation. In Holland, the reclamation by draining of large areas of waste sandy heath and moorland has met with difficulties from this cause; earlier investigations showed that heavy dressings of urban refuse gave some measure of control; such refuse contains copper salts, and later work has shown that copper sulphate alone was most effective. Liming such soils increased the trouble, presumably lowering the availability of the copper and apparently also removing the small amount of available manganese. Now the observations of C. S. Piper and of D. S. Riceman and C. M. Donald have shown that the 'coastal sickness' attacking grazing sheep in certain coastal areas of South Australia and the poor crops of cereal obtained from the same soils, similarly yield to treatment with copper salts. Dressings of 28 lb. of copper sulphate to the acre gave much improved yields of wheat, oats and barley, and a new feature is the fact that the original soil in these cases has a very high content of calcium carbonate and a pH between 8.5 and 9.0. The same dressing of copper did not effect much improvement on pastures on these soils, but there is evidence that higher dressings of copper or possibly treatments including other elements such as iron, will greatly improve the pasturage. The experimental work with the South Australian soils is described in Pamphlet No. 78 of the Council for Scientific and Industrial Research, Melbourne.—(*Nature*, Vol. 142, No. 3599, p. 760, 1938.).

BANANA DISEASES.

XII.—Diseases of the Banana in Haiti, with Special Reference to a Condition Described as "Plant Failure".

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I.—Introduction.

At the present time the production of commercial Gros Michel bananas in the Republic of Haiti amounts to approximately 1,500,000 bunches per annum, the fruit being harvested at the grade described as "heavy ¾-full" and exported to the United States of America. Much of the fruit is produced, in ravines and fertile hillside pockets throughout the Republic, by peasant enterprise, but on the plains extensive irrigated plantations have now been established on a "share-the-profit" system, entered into between peasant proprietors and the company responsible for the export industry. Almost without exception, throughout the vast alluvial plains, a considerable degree of alkalinity is the prevailing condition. This fact, in conjunction with the observation that many Haitian soils have been under almost continuous cultivation for centuries, with vicissitudes in the use (and abuse) of irrigation systems, gives to the cultivation of the Gros Michel banana — a plant notoriously exacting in its requirements — an interest that is in many ways unique.

In addition to Gros Michel, several varieties of plantain, and Dwarf Cavendish, Congo and Lacatan varieties are grown abundantly throughout Haiti.

A very thorough opportunity was afforded the writer of observing agricultural conditions throughout the Republic, particular attention being devoted to the extensive plantations established on the alluvial plains. When due consideration is given to the general status of agriculture among the peasant communities, the nature of the territory to be taken into cultivation, and the special problems of organisation, tillage and irrigation to be tackled, the progress made in a few years under the management and guidance of the operating fruit company has been indeed remarkable. It is generally considered that a sound agricultural tradition is long in the making: nevertheless the writer has seen in Haiti examples of plantation organisation and soil management that would compare favourably with the best in other parts of the Caribbean, and this after only a few years of instruction and demonstration.

The principal problem of the banana industry is the maintenance of production and quality of export fruit: two factors inimical to successful commercial enterprise in Haiti are of outstanding importance at the present time. These are:—

(i) Plant failure due to unfavourable soil factors;

(ii) The spread and intensification of Cercospora leaf disease (Sigatoka Disease).

In some districts the spread of Panama Disease and of Virus Heart Rot Disease also requires careful attention. Among subsidiary factors are the several stem and leaf diseases. The two major diseases are treated first; thereafter the order of arrangement followed is approximately that adopted in "Diseases of the Banana". Except where specially indicated, the diseases described were those observed affecting the Gros Michel banana.

II.—Plant Failure.

A condition of the greatest economic importance prevalent in banana plantations throughout the Republic, and here for convenience described as "Plant Failure", is characterised by a decline, soon after the establishment of plantations, in the production of quality export fruit.

(i) Symptoms.

(*a*) After an initial period, during 5–10 months in new plantings, of characteristic rapid growth and normal leaf development, or during the second or third year in plantations not previously affected, an abnormal condition of leaf failure, premature debility or death, becomes apparent. In many instances this condition is particularly noticeable about the time of shooting of the bunch. The filling out of the bunch accordingly has to be accomplished by a diminished and insufficient number of leaves, with inevitable consequences in respect of its rate of growth, size and quality. This condition may be general throughout the plantation and is particularly noticeable in localised areas.

(*b*) In different localities, and according to the age of the plant, a variety of leaf symptoms may be observed. In young plants, 5–10 months old, the older (lower) leaves may lose their normal full green colour prematurely and become yellow, yellow-brown, dirty yellow and streaked, and spotted by secondary leaf fungi. Later the leaves become brown, and if the petiole is unbroken, permitting of injection with water from below, of a dark brown colour, constituting what has been described as "black leaf". Some young plants may thus be seen carrying two or three brown leaves and one or two yellow-brown leaves, or there may be a cluster of brown leaves hanging down. In older plants, yellow, and discoloured greenish-yellow, brown and fallen leaves develop prematurely in

acropetal succession, so that bearing plants are left with an abnormally small number of leaves to cater for the important period of bunch development.

In some plants affected leaves are heavily spotted with secondary fungi ; in others, brown bands and browning of the leaf-tips, as in weevil-borer infestations, are of common occurrence. Marginal browning or "burning" of the type that accompanies "salt scorch" is not uncommon.

(*c*) In some areas, under the prevailing conditions of low relative humidity and exposure to the fierce sunlight, leaves are discoloured, particularly along the mid-rib and on the blade on the southern exposure, to a dingy, yellowish colour. Such leaves have a dry appearance and may be more or less crinkled, with abnormal twisting at the distal end. Young rolled leaves may also show abnormal twisting and evidence of sun scorching.

(*d*) In the second or third year, leaves of affected adult plants appear to be lacking in length and breadth, and tend to form an abnormal erect cluster round the "throat", instead of the graceful spread typical of normal healthy plants. The leaf blades droop early in the morning, and this effect, in conjunction with the leaf colours described above, gives the plants what has been described by cultivators as a "sleepy" appearance. The typical waxiness of Gros Michel leaves is often absent.

(*e*) Where the petiole of affected leaves joins the trunk or pseudostem, a black mark is typically present. With the progress of ageing or senescence in the leaf, this black mark increases in size and is seen to be associated with a localised water-logging of the petiole-pseudostem tissue, this being caused or accompanied by the activity of micro-organisms of the soft-rotting fermentation type. As these localised blackened regions increase in number as leaf after leaf becomes affected, the trunk acquires an unhealthy, pale yellow or pallid green appearance. This condition of the trunk is very general throughout Haiti where Plant Failure occurs.

(*f*) From the time bunches are "shot", they are seen to be short-fingered and not infrequently with the top hand (Trade: bottom hand) considerably separated from the second hand, an arrangement which is normal in some varieties but quite abnormal in the Gros Michel. As bunches are frequently slow in filling out, the main-stalk takes longer to reach the vertical position and fingers accordingly develop curvatures which spoil the symmetry of the bunch. At harvesting, bunches are short-fingered, light in weight, of irregular symmetry, and in general lacking that luxuriance of growth by which "quality" in this variety is assessed by the Trade. Additional evidence of abnormality in the bunch is seen in the continued adherence of the lower male flowers and in the formation of a small secondary bunch.

(*g*) In some instances the stature of the plant may be reduced, but as a rule the normal tall Gros Michel stature is retained.

(ii) Possible Contributory Conditions.

In relation to the symptoms described above, and consistently observed in all parts of Haiti, careful consideration has been given to the agent or agents capable of causing the observed condition. Important contributory factors, to which attention must be given in attempting to reach a precise diagnosis, include the following:—

(*a*) The prevailing low relative humidity of the atmosphere and high day temperatures, whereby evaporation from the leaves will be greatly accentuated.

(*b*) The insufficient rainfall, and the fact that most districts require irrigation ; such irrigation requirements are met by rule-of-thumb applications and are not based on any scientific data as to what particular Haitian soils require.

(*c*) The presence of salt in many districts.

(*d*) The presence of high pH values (7.5–9.2), and the existence, in all areas where this type of plant failure has been observed, of undesirably high concentrations of alkali of the type so far indicated by analysts as bicarbonates of the sodium-calcium complex.

(*e*) The fact that the areas utilised for banana cultivation are in no case virgin lands, but, on the contrary, have been depleted by centuries of cultivation and abuse ; in addition to the possibility of essential elements such as iron being rendered unavailable by the alkali complex referred to above, chemical analyses indicate, in different instances, insufficient quantities of nitrogen, potash and phosphorus, the insufficiency of organic matter being general (except in some natural peat formations).

(iii) Cause of Plant Failure : Botanical Aspect.

Plants showing well developed symptoms, as described above, were examined in different localities with the following negative results:—

(*a*) The internal tissues of the pseudostem and bulb (or rhizome) were invariably clean and free from borer infestations or disease due to micro-organisms.

(*b*) The main root system was abundantly developed and main roots were normal and free from disease.

By contrast with the condition of the thick main roots, the fine lateral rootlets, which are chiefly responsible for the uptake of water and minerals in solution, were found to be notably subject to injury and death as a result of the action of some adverse soil factor. In an examination of a considerable number of root systems, including those of both young and old plants, it was found that premature dying (recognisable by the change from white to a pale to deep purple colour) of a very high percentage of the absorbent rootlets, was a generally prevailing condition, irrespective of the soil type or its state of tilth, the indication being that the causal factor was probably the same throughout. In the circumstances of the investigation, the requisite cultural and microscopic studies could not be undertaken, but all the observations made are consistent with the view that death of the rootlets is not due to the activities of parasitic micro-organisms but to deleterious chemical factors. The same type of rootlet disorganisation is typically found in poorly aerated stiff clay soils and where planting has been undertaken on wet land before preliminary drainage operations have been sufficiently carried out. Instances have been observed in Haiti where those factors also apply.

In conjunction with the high rate of evaporation from the leaves under Haitian conditions, the presence of a soil factor (or factors) responsible for the premature disorganisation and death of the rootlet system would, in the writer's opinion, fully account for all the symptoms described above.

(iv) Probable Nature of Deleterious Soil Factor.

Any comment as to the precise nature of the soil factor or factors adversely affecting the root-system must, at this stage in the investigation, of necessity be speculative. Of the several possible contributory conditions set out in Sub-section *(ii)* above, toxicity exercised by the high alkali (? bicarbonate) content of the soil, and inadequate supplies of essential minerals, seem to be those most likely, either separately or in conjunction, to account for the observed condition. In most areas, the concentrations of common salt alone are not sufficient to cause the observed root killing. Because of the complex interactions of the several chemical ingredients of the soil, and the fact that any change in one is attended by modifications in others, the assignment of root injury specifically to one or more particular factors may well prove a matter of some difficulty.

(v) Remedial Measures.

As a practical issue it appears that remedial measures may be sought conjointly along two main lines, with some hope of success:—

(*a*) By effecting a sufficient modification of the prevailing alkaline condition of the soil.

(*b*) By replenishing the nutritive elements essential to commercial banana production.

Because of the prolonged period during which Haitian soils have been depleted by continuous cultivation (without adequate maintenance of essential minerals and organic matter) it seems probable that the application of fertilizers must become general if the output of quality commercial fruit is to be maintained.

Important questions that must be answered before remedial measures can be put on an economic basis (*i.e.* maximum result for minimum expenditure, since any treatment will represent an increase on existing production costs) include the following:—

(*a*) What are the simplest measures by which the existing alkalinity can be sufficiently modified in relation to growth conditions required by the Gros Michel ?

(*b*) What fertilisers must be used and in what quantities ?

(*c*) To what extent can the undesirable action of soil alkali be offset directly by fertiliser treatment alone ?

From such fertiliser experiments as have been carried out, and from various ecological observations, the indications are that many of the symptoms of "Plant Failure" disappear under suitable manurial treatment. On the other hand, agricultural treatments alone, such as forking, draining, pruning, &c., while they improve the condition of plantations, apparently do not eliminate this malady. Whether manipulative and manurial treatments can be applied to effect a permanent improvement, with concomitant increase in productiveness, is the question that calls for immediate solution. It has been recommended that suitable scientific staff should be recruited to carry out the necessary analytical and experimental work.

Attention may be directed to a banana problem in Australia, where a type of plant failure, with many symptoms identical with those observed in Haiti, was remedied by the application of fertilisers. ("Diseases of the Banana", pp. 173–176.)

III.—Alkali Chlorosis.

Well marked cases of Alkali Chlorosis, which are considered to indicate an intensified condition of the Plant Failure described in the preceding Section, are found in certain districts in moderately extensive areas, and throughout the Republic in localised pockets where soils of excessive alkalinity are known to exist.

A careful survey of symptoms was made at Delugé, where, in some instances, whole patches, involving many plants, are of a bleached, whitish appearance. The soil in this region is known to be alkaline, the alkalinity being of particular severity to the banana in localised areas. Plants growing in limestone ravines and hillsides throughout the Republic also show strikingly chlorotic foliage.

(i) Symptoms.

Alkali chlorosis is denoted by the following symptoms:—

(*a*) Leaves, stems and bunches may show every stage in chlorophyll deficiency from a slight bleaching of the normal green colour to an almost complete yellowish white. Leaves may be affected at all stages. In some instances the partial absence of chlorophyll gives the leaves a "shot" or striped appearance, similar to the markings present in a virus disease.

(*b*) A brown scorching or rotting of young and old leaves, along the margin, on the mid-rib, or over the leaf-blade, frequently accompanies the development of the chlorotic condition.

(*c*) When young plants are affected, characteristically wrinkled, arrow- or irregular-shaped leaves are of common occurrence in conjunction with the prevailing chlorosis. Such symptoms may be readily observed in plants 4–6 feet high. In some instances, a period of apparently normal growth precedes the transition to the chlorotic condition. As in the case of Plant Failure, the plant may develop normally until, at a certain stage, a well marked change and growth-arrest take place.

(*d*) In adult plants, the leaves tend to have a characteristic rigidity and erectness. Such leaves show wilting of the blades at an early hour in the morning.

(*e*) Adult plants do not attain to their normal height but remain stunted, with short, thick trunks, the throat where the bunch emerges being only some 7–8 feet from the ground.

(*f*) When bunches are "shot" they are seen to be short-fingered. As growth is slow, the young bunch tends to remain for an unduly prolonged period in a horizontal or semi-horizontal position, with the result that the fingers acquire a twisted appearance and the normal symmetry and compactness of the bunch are lost. Even in well advanced bunches, the abnormal curvature of the main-stalk may still remain clearly marked. Whereas fingers tend to be short over the whole length of the bunch, the internodes between the hands are often abnormally long, so that the large top hand may be quite separated from the rest of the bunch.

(*g*) The intermediate flowers below the bunch tend to remain adherent longer than is usual in normal bunches, and the formation of a small secondary bunch, between the bud and the main bunch, is of common occurrence. The male flowers also show a tendency to adhere to the main-stalk.

(ii) Treatment.

That the malady under consideration is a well defined example of alkali chlorosis is evident and that it represents an extreme condition of the more generalised Plant Failure described in Section III seems probable. Reference to standard works indicates that chlorosis may be treated in a number of different ways, but here again, as in the matter of Plant Failure, the specific economic treatment to be adopted should be based on a thorough investigation of the chemical composition of the soil solution and a precise knowledge of the toxic alkali present. Leaching with ample supplies of irrigation water, drainage, incorporation of organic matter, applications of sulphur or gypsum, application of iron salts, various fertilisers, &c., are all possibilities which could be tried out empirically, but, in the writer's opinion, the best and most economic approach will be that based on an adequate soil investigation.

IV.—Cercospora Leaf Disease (Sigatoka Disease).

With special reference to leaf disease, an inspection was made of banana plantations throughout the Republic, and it is now possible to specify the status of this disease, as observed during September – October, 1938, with some degree of precision.

Using Trinidad experience as a guide, the intensity of an infection of *Cercospora musae* may be referred to one of the following categories:—

(i) No leaf spotting.

(ii) Occasional isolated leaf spots.

(iii) General light spotting of leaves, or light spotting in certain areas of the field.

(iv) General light spotting, with localised patches in which many leaves per plant are severely affected (sometimes described as "badly burned").

(v) General severe spotting, the majority of the leaves in each plant being "badly burned", but bunches, though slow in filling out, still apparently normal.

(vi) Very severe spotting, plantations of a prevailing brown or scorched appearance, prematurely ripening bunches on the plants, or bunches found to be abnormal after harvesting.

Examples of all of these several categories, *with the exception of the final epidemic condition* (*No. vi*), have now been observed in Haiti. In short, there is every indication that the progress of the disease in Haiti is in conformity with what has been experienced elsewhere. There is no difficulty at the present time in observing the development of Cercospora lesions, or spots, from the minute yellowish-brown stage onwards, *i.e.* leaf infections have been sustained over a considerable time, and spotting is appearing progressively as leaves increase in age.

As indicated above, there is now definite evidence that *Cercospora musae* can cause serious leaf spotting under Haitian conditions, and in some areas it may be anticipated that from 6–12 months hence the quality of the fruit produced will be more or less seriously affected. Whether this will apply to certain areas only, or whether the final severity of the infection will become general, cannot yet be determined. The prevailing conditions of low humidity, low rainfall and short dew period encourage the hope that in some areas the disease may remain commercially unimportant, but this remains to be seen. In the meantime, where possible, preventive measures should be undertaken at an early stage, and the planting community made aware of the danger that will follow in the train of an intensification of the disease.

V.—Panama Disease.

Instances of Panama Disease (*Fusarium oxysporum cubense*) in the Gros Michel were observed in the Artibonite district and a definite diagnosis obtained by culturing the pathogenic organism. Affected stools are being treated with "killer (heavy gas) oil" according to established practice.

At the present time, the evidence of the distribution and behaviour of Panama Disease in Haiti is somewhat conflicting, and it cannot yet be said whether or not it is likely to progress to epidemic proportions. In most areas the number of cases so far observed is small, the indication being that the disease had been introduced through the use of defective planting materials. In other instances it seems probable that cases of Moko (Bacterial Wilt) Disease and of Virus Heart Rot Disease have been erroneously regarded as Panama Disease cases.

As a result of serious neglect, malpractice and floods, the disease has gained a stronghold in the plantations round Jacmel and is likely to be the cause of considerable losses. This is a clear case where judicious official action, at an early opportunity, is required to control the disease.

VI.—Bacterial Wilt Disease (Moko Disease).

This disease, due to *Bacterium solanacearum*, was typically observed in the Moko or Bluggoe plantain. In certain cases of wilt disease in the Gros Michel the external symptoms were also indicative of the bacterial infection. A careful examination of the internal symptoms confirmed this view, so that it may now be accepted that all cases of wilting in the Gros Michel are not necessarily due to Panama Disease. Judged by the widespread distribution of healthy Moko plantations, the virulence of Moko disease in Haiti is evidently considerably less than that previously reported in Trinidad and elsewhere.

Affected stools should be destroyed by "killer oil" treatment. By exposing affected soil to sunlight and desiccation, the pathogen can be sufficiently destroyed to permit of replanting.

VII.—Marasmius Stem Rot; and Bulb Rots.

(i) Marasmius Stem Rot.

On a plantation in the Cap Haitien district, where flooding had been followed by very dry conditions, typical examples of Marasmius Stem Rot (*Marasmius semiustus*) were observed. Abundant fructifications of the fungus were found on decaying banana trash in moist areas. *Marasmius semiustus* usually makes its attacks on plants debilitated by adverse cultural conditions, drought or partial drought being an important factor.

(ii) Bulb Rots.

An internal rotting of bulbs, following borer injury, was observed in an Artibonite plantation. This was of the type described in Jamaica as "black head disease". It is unimportant. In some districts borer injury (due to *Cosmopolites sordidus*) is almost absent; in others, the infestations are sufficiently severe as to require special attention, *i.e.* the careful chopping up of all pseudostem and bulb tissue, and trimming felled trunks close to the soil level.

VIII.—Heart Rot.

A considerable number of cases of Heart Rot have been observed in the Artibonite district, the disease being associated with plants in which leaves had been broken by wind action, or where leaf-pruning, subsequent to wind damage, had been carried out.

Broken leaf-stalks or petioles, and injured heart leaves, become infected with a bacterium of the soft-rotting fermentation type. The putrescent condition moves rapidly down the trunk and eventually causes a more or less serious soft-rotting, odoriferous decay of the bulb or rhizome. Such plants must be pruned out. In severe cases, killing of the entire stool with gas oil may be necessary. This disease has many points in common with a condition described by Prescott in Central America and by the writer in Trinidad (*see* "Diseases of the Banana", pp. 218–222).

The indications are that prevailing soil conditions are in some way responsible for the comparative severity of this disease in Haiti. This type of Heart Rot is quite distinct from that associated with the virus disease described below.

IX.—Cigar End (Stachylidium Theobromae).

This disease, which takes its name from a characteristic rotting of the tip or distal end of fruits under plantation conditions, has hitherto been described as chiefly affecting the Cavendish variety. Under Haitian conditions the disease occasionally occurs on the Gros Michel, and probably indicates that the bunch has been produced under unfavourable conditions.

The dry-rotted appearance of the fruit-pulp where the fungus has penetrated is the same in the Gros Michel as in the Cavendish variety. This disease is commercially unimportant, only one, two or three fruits per bunch being affected.

X.—Physiological Diseases of Fruits (Plantation).

(i) Sun Scald.

Where bunches have been excessively exposed to sunlight, evidence of the condition described as sun-scald has been observed, the individual fruits being of a dry, pale yellowish-green appearance. At the bend of the main-stalk, severe scalding and cracking are of frequent occurrence in certain areas.

(ii) "May" Bunches.

Irregularly developed bunches characterised by twisted fingers and a general loss of symmetry are of common occurrence, particularly at certain seasons in Haiti. Elsewhere, *e.g.* Canary Islands, these have been described as "May" bunches. They are indicative of a check in growth or slow growth following the appearance or "shooting" of the bunch. In some instances "May" bunches merely reflect the slowing down of growth under winter conditions, but, in others, they are definitely symptomatic of unfavourable soil and climatic conditions. This latter aspect is of very great commercial importance in Haiti and is fully considered in Section II above.

XI.—Other Leaf Diseases.

Large dark spots and large pale spots or marginal blotches of the types attributed to *Helminthosporium torulosum* and *Cordana musae* respectively are of general occurrence. These are not economically important except in those instances where their severity may be taken as being indicative of unfavourable growth conditions.

The leaf marking described as "speckle", and attributed to *Chloridium musae,* is common in moist areas but is not economically important.

A considerable amount of damage to leaves is incurred in some areas as a result of the activities of a round purple scale, which had previously been identified as *Chrysomphalus personatus.* In the Jacmel district some heavy infestations of leaves by a white scale were observed.

Hail injury to leaves and petioles was occasionally observed.

XII.—Virus Heart Rot Disease.

(i) Symptoms.

A disease which may be described as Virus Heart Rot Disease was observed in the new cultivations at Delugé. The disease is characterised as follows:—

(*a*) By the presence of yellow striping, interrupted streaking, or mottling on some or most of the leaves, the type of striping being that which is commonly associated with virus diseases. The striping may also be observed on the young arrow-shaped leaves of young suckers, indicating that the malady, as in other virus diseases, tends to become systemically distributed through the whole stool. In older leaves, the streaking becomes intensified and very easily observable, as streaks of dark purple and blue colour make their appearance.

(*b*) In some plants there may be a tendency to premature leaf-falling, so that the early symptoms of some types of wilt disease may be simulated. A slight congestion of the leaves of young suckers also indicates an abnormal pathological condition. Stem splitting in adult plants has also been observed.

(*c*) Associated with the mottled condition of the leaves, a localised necrosis or death of the tissues of the pseudostem or trunk takes place. This consists in the development of small, water-soaked pockets of tissue, which later become yellowish, brown and eventually of a dark blood-red colour, such pockets being distributed over the length of the trunk, in both outer and inner leaf sheaths, and finally in the bulb itself. In the outer green leaf sheaths, the presence of internal necrosed pockets in the earlier stages of their development may impart to the trunk what has been described as a "bluish appearance".

Plants in which the heart rot condition is acutely developed are killed or are quite incapable of producing commercial fruit.

(ii) Occurrence and Importance.

In 1930 a disease of this type was first described in Australia, subsequent experiments proving it to be a true type of virus disease (mosaic disease or infectious chlorosis) the aphis, *Pentalonia nigronervosa,* being the agent responsible for transferring the disease from plant to plant. This disease has caused considerable losses in Australia and is now treated with the same severity as Bunchy Top Disease (a virus disease of major importance). Last year, the writer observed what appears to be the Australian Virus Heart Rot Disease in Guadeloupe (French West Indies), causing a considerable amount of loss in the Congo banana (*Tropical Agriculture,* XIV, 10, 1937). Now it has been observed in Haiti on the Gros Michel. As the insect vector responsible for spreading the disease has also been observed in Haiti, it follows that, given favourable conditions, this disease might become considerably more widespread and destructive than it is at present. It should accordingly be treated with the greatest attention.

(iii) Treatment.

Well defined cases of the disease should be carefully and fully demonstrated to plantation managers and to members of the official Plant Protection Service. Thereafter, all plantations

should be carefully surveyed for cases, and all such cases immediately eradicated using the gas-oil treatment. The disease should also be made *notifiable* and subject to official supervision and treatment.

A virus disease of a type already well known in the West Indies, characterised by a streaky leaf mottling but without the heart-rot condition, was observed on the green-red banana. Although this disease is not in itself important, it should also be eliminated for obvious reasons.

XIII.—Thrips Injury to Fruit.

A more or less profuse pin-head spotting of fruits is now known to be due to a species of thrips, *Frankliniella insularis*. The insect normally lives in leguminous crops and apparently transfers its activities to the banana at the time when bunches are being shot. As severe thrips spotting may cause commercial bunches to be rejected, it follows that the leguminous cover crop, as well as other leguminous weeds, should be cut down and mulched prior to the general shooting of bunches in new plantations.

Acknowledgments.

The writer is deeply indebted to the Standard Fruit Company of Haiti for the opportunity afforded him of extending his knowledge of the banana and its diseases under the interesting cultural conditions peculiar to the Republic. In particular he wishes to thank Mr. John Brownson and Mr. M. O. V. ffrench-Mullen for the kind assistance they have given him in enabling him to see all matters relevant to banana cultivation.

SOIL NUTRITION.

[*The following article which is of considerable interest is reproduced from Soils and Fertilizers, Vol. I, No.* 5, 1938, *pp.* 181-183, *issued by the Imperial Bureau of Soil Science.*]

We venture to suggest that a new branch of soil science be recognized, namely, soil nutrition. Soil nutrition would be related to general pedology in much the same way as plant nutrition is to botany or animal nutrition to zoology. At present we speak of supplying nutrients to the soil when we mean supplying them to the plants that grow on the soil. A clearer distinction could be made between soil nutrition and plant nutrition —a distinction which might relieve the soil chemist from spending so much of his time on what is essentially the plant physiologist's job and enable him to pay closer attention to the soil.

It must be emphasized that the term nutrition, as applied to soil, is used in an analogous sense to plant and animal nutrition, for want of a better word. A properly fed plant is in a condition to manufacture animal foods in which plant nutrients play a quantitatively subordinate part. By analogy, a properly fed soil is one which is in a condition to manufacture plant nutrients in a form in which they are available for plant growth. Most soils possess an almost limitless supply of the major and minor plant nutrients (and toxins) and, when properly nourished, give them up to, or withhold them from, the vegetation in the quantities required for normal plant growth. The mechanism of this remarkable process should be the subject of the soil nutritionist's study. Soil nutrition may not be of much practical importance in agriculture, where plant nutrition is becoming increasingly independent of the soil, but it is fundamental to the science of the soil. Agriculture tends to regard soil as a somewhat inefficient substitute for sand or water as a medium for conveying nutrients to the plant, but where the hand of man is absent plant growth depends primarily upon the processes of soil nutrition, as much as the welfare of the animal world depends ultimately upon plant nutrition. Soil nutrition may thus be regarded as a fundamental process in the cycle of life and worthy of the closest scientific study apart from any practical advantages that might accrue from such study.

The study might start by a consideration of soils showing obvious symptoms of malnutrition. Malnutrition is not necessarily indicated when a soil responds readily to ordinary manurial dressings, since such response may be due merely to the abnormal demands of a heavy crop being met by the applied nutrients, and may have nothing to do with the ability of the soil to render its own supply of plant nutrients available. Malnutrition shows itself rather when some physical or chemical treatment produces an increase in vegetal production out of all proportion to the amount of plant nutrients—if any—applied. Such a disproportionate increase implies that the production of available nutrients *by the soil* has been stimulated by the treatment.

Simple cases of feeding ill-nourished soils are exemplified by drainage and cultivations which, *per se*, produce increased yields. The ways in which such operations feed the soil are believed to be known, but there are certain other cases of malnutrition which the soil chemist finds difficulty in explaining according to orthodox plant-nutrition theory. Some of these cases are capable of quite simple explanation, others demand the exercise of imagination. A few examples may be given.

Cultivated crops in the tropics sometimes respond readily to organic manures where artificials are without effect. It has been suggested that the readily available artificials "burn" the crops, while the organically combined nutrients are released more gradually. A particular case is illustrated by the remarkable response obtained to small dressings of farmyard manure (2 tons per acre) in Nigeria, where complete artificial-fertilizer treatment was ineffective.* The extra nutrient uptake in the manured plants was greater than the amount supplied by the manure. Later work has shown that much the same response is obtained by applying superphosphate in the absence of nitrogen and potash.

Large yield increases have also been obtained in South Russia by applying enormous quantities of superphosphate to lateritic soils, although there was little or no recovery of added phosphate in the crop. Here the phosphate may act by precipitating toxic aluminium in the soil.

A somewhat analogous abnormal response to phosphate has frequently been observed in young conifer plantations on acid peats where growth may be 5-10 times as vigorous on slagged plots as on controls. Under these conditions other artificial fertilizers (including superphosphate) are without effect or are deleterious.

Mr. C. Rayner† has obtained remarkable results by using specially prepared composts, poor in nutrients, with conifer seedlings on strongly podzolized soils. The treated plants throve better than similar plants grown in fertile nursery soil, whereas the controls failed entirely. The composts, moreover, had no effect except when applied to very poor soils, in fact they sometimes depressed growth on good soils. There can be no doubt but that something other than a direct plant-nutrient effect is involved here. Dr. Rayner attributes her results partly to a stimulation of the mycorrhizal habit in the trees by the composts and, more generally, to a "change of direction of the biological activities responsible for humus decomposition". The origin of the compost material has a very marked influence on the efficacy of the product. Basic slag on these mineral soils has also a considerable effect which is not readily explained on the same grounds as the compost effect.

Dhar, in India, has made alkaline soils productive by applying molasses, poor in plant nutrients. The decomposition products of the molasses presumably neutralize soil alkalinity besides stimulating micro-biological activity.

In all these cases plants on the treated or "fed" soils took up more nutrients, in comparison with the controls, than could be accounted for in the nutrients applied, that is, the soil was put into a condition where it could feed the plants from its own reserves. This is a soil's natural and primary function. When it performs that function it is healthy; when it is merely a temporary receptacle for added plant nutrients and cannot itself feed a crop it is unhealthy, even though it may still yield a profit to fertilizing. The medical profession has latterly decided that the study of health—if time can be found for it—is just as important as getting sick people back to a workable condition, and the pedological profession—if it could find time—might equally pay attention to discovering what a soil requires for normal functioning as well as to making fertilizers give their maximum return when applied to the soil.

Numerous facts are already available with regard to soil health but they have been considered more in relation to their bearing on plant than on soil nutrition. The physico-chemical condition of the soil is obvioulsy of first importance, and possibly the main function of soil nutrients is to maintain a regulated series of precipitation and solution reactions in the soil mass. There is nothing very novel about the concept of soil nutrition; the advantage of treating it as a distinct branch of pedology would be that, apart from drawing the pedologist's attention to the soil, it might bring into their proper relationship such apparently diverse phenomena as the failures of pine transplants on acid heaths and of farm crops in the tropics. They may have the same kind of relationship to one another as two such dissimilar phenomena as, *e.g.* potash-deficiency symptoms in bananas and in sugar-beet. Certain effects of minor elements in the soil may admit of more plausible explanation as soil-nutrition than as plant-nutrition phenomena.

The examples of soil malnutrition cited above suggest that phosphate may be just as important a soil nutrien as it is a plant nutrient, and that the phosphate requirement of a soil may have a more literal meaning than that usually given to it. Lime requirement is certainly more a soil-nutrition than a plant-nutrition term. Nitrogen is obviously a soil nutrient, but in organic combination and not as ammonium or nitrate. We cannot think of any evidence that potash is an essential soil nutrient. The claims of other commonly occurring constituents such as silica, iron and aluminium as soil nutrients deserve consideration. Humus may—almost certainly does—contain soil nutrients other than nitrogen and phosphorus, but what these are and how they function is unknown. A knowledge of the basic principles of soil nutrition should go far towards elucidating the chemistry of humus. It should also enable us to correlate the working of the various "cycles" of weathering, organic matter, vegetation, micro-organisms, &c.,—and to obtain a clearer picture of the intricate internal mechanism of soil.

* *Emp. J. Expt. Agric.*, 1, 1933 (113-121).

† *Forestry*, 10, 1936 (1-22).

REVIEWS.

THE COLONIAL EMPIRE AND ITS CIVIL SERVICE.

By C. Jeffries, C.M.G., O.B.E., with a Foreword by the Rt. Hon. Lord Harlech, *The University Press*, Cambridge, 1938, pp. 259, *Price* 10*s*. 6*d*.

This is the first comprehensive account of the development of the Colonial Service and of the position it occupies at the present time. A singularly appropriate time has been chosen for its appearance, when the problems of the Colonial Empire are being subjected to a more searching scrutiny than ever before.

The book, as one of its aims, sets out to explain the reasons for the radical changes which the Colonial Service has been undergoing during the past few years and what measure of improvement has been effected. The introduction gives an outline of the extent of the Colonial Empire, occupying an area of nearly two million square miles with a population of about 50 millions, characterised by a surprising diversity of peoples and by a geographical discontinuity, which includes vast continental territories and tiny oceanic islands. The greater part of this area and of this population lies within the tropics.

The author divides his work into two parts, the first dealing with the development of the Service from its inception up to the introduction of the policy of unification in recent years. The Service as it exists to-day is described in the second part, which includes, among others, chapters on the administrative, legal, medical, forestry, agricultural, veterinary and other unified branches. Detailed information as to the conditions of employment in the Service is given in one of the longest chapters, and the methods of recruitment and training of candidates are dealt with under the various branches to which application has been made for admission. Thus, a candidate for the Colonial Forest Service receives a course of post-graduate training at the Imperial Forestry Institute at Oxford and for the Colonial Agricultural Service at Cambridge and at the Imperial College of Tropical Agriculture in Trinidad.

Concluding chapters give an account of the Colonial Office and a retrospect and prospect. A number of interesting notes, including a summary of appointments made in the years 1921 to 1936 and a map of the Colonial Empire, are given as appendices.

In the Foreword by Lord Harlech, the book is warmly commended to those who are looking to the Colonial Empire as a field for their life work and to those who wish to know more of its intricate and absorbing problems. The author is undoubtedly to be congratulated on the compilation of a most useful book, as much to read as to which to make reference, which is probably to become the standard work on the subject.

E. McC. C.

THE PRINCIPLES OF SOIL SCIENCE.

By A. A. J. de Sigmond, translated from the Hungarian by A. B. Yolland and edited by G. V. Jacks, with foreword by Sir John Russell; *Thomas Murby & Co.*, London, 1938, pp. 362, 34 illustrations, 4 plates, *Price* 22*s*. 6*d*.

Professor de Sigmond is one of the best known continental soil specialists, particularly through his work on soil classification and the methods of reclamation of alkali lands. His "Principles" is divided into four parts entitled, Soil Genetics, Agronomy, Systematics and Cartography. In the first part, consideration is given to the chief soil-forming factors comprising parent rock, climate, ground-water, vegetation, micro-organisms, and animals including man. These are dealt with in turn in nine chapters. The section on Agronomy mainly consists of a discussion on soil chemistry in relation to fertility. In the section on Systematics, Professor de Sigmond presents his own scheme of soil classification, which is mainly based on the chemical composition of the soil. It is here described for the first time in English. Some twenty-five soil orders are differentiated, under such titles as hydrogen-soils, calcium-soils, sodium-soils, brown earths, red earths, yellow earths, turf soils, desert soils, grit soils and dust soils, which sufficiently indicate the general basis of the classification. Soil mapping and soil maps are considered in the last three chapters. There are a subject index, an author index, and four plates, the first of which shows the distribution of the soil orders in Europe, and the others the main profile features of the soils of Hungary.

Most of the literature cited in this book was originally published in the German, French and Russian languages, so that the English-speaking reader, who may be somewhat biased by having studied soil science solely in British or American books and publications, should benefit greatly from this exposition of the subject from another point of view.

F. H.

* * *

STATISTICAL TABLES FOR BIOLOGICAL, AGRICULTURAL AND MEDICAL RESEARCH.

By R. A. Fisher and F. Yates. *Oliver and Boyd.* 1938.

The worst of modern statistical work is the labour it entails in computing. Fortunately various labour saving devices have been invented which keep the burden within tolerable limits. Among these, some of the most important are books of tables, in which statistics in common use are computed and tabulated once and for all. Barlow's Tables, log tables and the tables in Fisher's "Statistical Methods" are part of the standard

equipment of the statistician. Fisher and Yates have now brought together in one volume all the tables in common use, and added a number of valuable new ones.

The use of the tables is explained in detail, with examples, in the introduction, and the statistician will find that there is no need to refer back to text books or original papers to refresh his memory on the working of a method.

The distribution of the variance ratio as well as that of z is given for those who prefer it, and the table of X^2 is supplemented by Table VIII Tests of Significance for 2×2 Contingency Tables, in which allowance is made for the asymmetry of the actual distribution when the smallest expectation is below 100.

Tables IX-XIV giving probits and angular transformations will be invaluable in studies of the incidence and control of diseases and pests, genetical studies of metrical characters, and a wide range of experiments yielding data in which the variance varies with the mean.

Those responsible for field experiments will find the labour entailed in designing trials much reduced by the tables of Latin squares and balanced incomplete blocks.

There follow among others, tables for dealing with ranked data, orthogonal polynomials, logarithms, and natural logarithms, squares and square roots, &c., lists of random numbers and constants and conversion factors for weights and measures.

To produce such a complete collection of statistical tables, well printed and on good paper for 12*s.* 6*d.* is an achievement with which the authors and publishers may well be pleased. For the working statistician the volume will rapidly become indispensible, both on account of the convenience of having all his tables in one place and because many of them are either not available or not easily accessible elsewhere.

J. B. H.

* * *

THE PRINCIPLES OF CANE SUGAR MANUFACTURE.

By J. G. Davies, *Norman Rodger*, London, 1938, pp. 144, 23 plates, price 11*s.*, post free.

The Principles of Cane Sugar Manufacture is a descriptive book dealing with the production of commercial sugar from sugar-cane. Its text is completely free from any complicated or highly technical discussion, either from an engineering or "process" point of view. Further, masses of figures and statistical data relating to capacities, rates of operation, and factory reports, are conspicuous by their absence. The different stages of manufacture are dealt with so interestingly, that the reader's attention is held until the end of the process when the sugar is safely in the bag.

The text is so simple and straight-forward, that it is easily understandable by the non-technical reader. This naturally limits the scope of the work, which will probably be read mostly by people who would like to know something of the working of a sugar factory, and by sugar technology students during their first year.

There are 13 chapters altogether, of which the first nine describe the working of a factory designed for making 96° Polarization raw sugar. Of the remaining five, Chapter IX describes the modifications necessary for producing Direct Consumption Sugars. Chapter X shows how Fancy Molasses are made. Chapter XI deals with methods of transporting cane to the factory, and sugar, molasses, &c., away from it. Chapter XII discusses the utilization of factory by-products, and Chapter XIII gives a concise summary of chemical control.

The book is printed on good paper and well bound. It is profusely illustrated with figures and plates, there being 17 of the former and 23 of the latter. It is publshed by Norman Rodger and may be obtained for the reasonable price of 11*s.*, post free.

R. D. E. Y.

* * *

LEXICON DE STRATIGRAPHIE.

Volume I: Africa, edited by S. H. Haughton, D.Sc., F.G.S., *Thomas Murby & Co.*, London, 1938. pp. 432, price 31*s.* 6*d.*

This book is the first of a series of publications decided upon at the XVth International Geological Congress held in South Africa in 1929. It aims at bringing together "definitions of all unit stratigraphical names that have appeared in geological literature" concerning Africa. Other subsequent volumes will deal with other continents in turn. Dr. Haughton, Director of the Geological Survey of South Africa, was appointed General Editor of the series, and was responsible for the compilation of this first volume; he has been aided by twenty-two collaborators, each an authority on the geology of his own particular section of the African Continent. The entries are arranged in alphabetical order, and each appears in the language of its author, most of them being printed, however, in either English or French. Each definition gives the original and the present-day usage of the term, its geological relationships, a list of chief fossils and full references to the literature.

As a book of geological reference, the volume should prove of considerable value to soil investigators and to agriculturists interested in soil origin. The printing and general get-up are excellent, and the utility of the book is enhanced by an index of entries arranged under countries.

F. H.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

A Promising New Cane Variety in Barbados.

By S. J. Saint.

This report gives various details of cane breeding work and trials of new seedlings. Among the more promising new varieties B 3013 is singled out for special discussion. As plant cane, this variety outyielded the standards in three out of four years, and markedly so in the years 1936 and 1937. The 1936 crop enjoyed a higher than average rainfall, while the rainfall for the 1935 crop was below average. The conclusion is that B 3013 will yield slightly less than the standards in years of low rainfall, but will give higher yields in years of average or above-average rainfall.

The most marked superiority of B 3013, however, is as a ratooner, even in low-rainfall years. Besides giving higher ratoon yields, it appears probable that it will ratoon profitably for a longer number of seasons. It retains its fresh appearance throughout the crop, and sprouts readily and strongly after being cut. In the per cent. of sucrose in cane, B 3013 is close to B 726, and superior to BH 10(12). Maturity experiments have shown that it ripens soon after B 726. It is an unusually sound seedling, showing little cane rot, and is comparatively little attacked by rats.—(*Inter. Sugar Journal*, Vol. XL, No. 478, pp. 397-98, 1938.)

* * *

An Experiment in Reconditioning Mill Brasses.

By H. Horton.

Bearing in mind the advances made in the improvement of white metals, it was decided to re-metal two old side brasses for 17 in. × 22 in. bearings, which had been worn to about $\frac{3}{8}$ in. below their original thickness, so as to re-build them to their original thickness. Two metals were selected for comparison, viz.: "Microid No. 9" for the pinion side (characterized by large cuboidal crystals of tin-antimony), costing 3*s.* 6*d.* per lb.; and "Microid All Duty" for the pintle end (having a fine micro structure), a relatively cheap metal, costing 1*s.* 6*d.* per lb.

First, the brasses were relieved over their whole area to within about $\frac{1}{2}$ in. of their boundaries, $\frac{1}{8}$ in. deep, and the edge undercut. In addition, a longitudinal key slot $\frac{1}{8}$ in. deeper and $1\frac{1}{2}$ in. wide, extending the same width, was cut, its edge being also undercut. Tinning was done by placing the brasses on a smith's coke fire and bringing them up to such a temperature that a stick of solder, when applied to the surface, was just melted. It was then seen that oil was exuding copiously from the pores of the brass, and at first sight it looked as though tinning might be a difficult operation.

Caustic soda could not be used, as its reaction with the zinc would destroy adhesion; nor did it seem advisable to use either pure or 50 : 50 tin, as this might prevent the bounding of the white metal by the formation of local alloys. Eventually the difficulty was overcome by using "Tinsall" preparation which applied with a wire brush at once gave a very good tinned surface. The brasses were prepared for casting by placing them on end securely bolted to a cast-iron plate, and the required thickness obtained by placing in front a mould made of $\frac{1}{8}$ in. black iron plate.

This was bent to the required arc, and secured to the brass itself by clamps and to the base-plate by bolts, the whole being finally made tight by a putty of equal parts of fireclay and asbestos kneaded with water, which was applied in liberal proportion around the base. Next a small coke fire was built around the brass so as to preheat it till a stick of solder when applied to the surface just began to run. Blow-lamps also had to be used to warm the top when actually casting. No provision for a header was made, but this would be desirable in standardizing the method.

In actually casting, while the brasses were being preheated, the metal was melted as close to the brasses as was convenient, so as to prevent under-cooling before pouring. In melting the metal, particular care was taken not to skim it, it being stirred with some pine sticks from time to time. Following this the coke fire was knocked away from around the brasses and the metal poured in as quickly as possible.

It was then agitated by means of wire rods of black iron until it set. As the contraction caused the surface to sink, fresh metal was added as required until the whole had solidified. Immediately this occurred, an air blast was turned on the sheet iron mould while the clamps were undone, the now white metal surface being exposed. To cool it out as quickly as possible, and prevent crystal growth, the metal was hosed with water. Lastly, the brasses were machined to size, and samples taken from the top and bottom to ascertain if there had been any segregation.

So as to examine the result of this experiment, the Chief Engineer at Moreton Central Mill ran a test in which the bearings were not water-jacketted. After crushing 66,000 tons of cane both bearings had their original thickness, and at no time could any sign of wear, nor of cracks be seen. In all, 102 lbs. of "Microid No. 9" and 138 lbs. of "Microid All Duty" were used for this reconditioning job.—(*Inter. Sugar Journal*, Vol. XI., No. 478, p. 404, 1938.)

The Editor requests that any subscriber who fails to receive *Tropical Agriculture* regularly should communicate with him immediately in order that the matter may be rectified.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Vitamin-D in Foodstuffs: The Value of Cacao-Shell.

In regard to food, judgment by the palate and by instinct has something to be said for it, but instinct and the palate are useless as a guide in the case of vitamins. There is consequently a great obligation on the part of food producers and manufacturers not to neglect the presence of vitamins in their products.

Vitamin-D is not widely distributed in common foodstuffs, being confined chiefly to fish, eggs, milk products, liver and the cacao-bean, the latter being the only vegetable product that contains it in appreciable quantity. In all cases, it is present in the fatty constituent. The narrow range and limited amount of Vitamin-D in foodstuffs raises the question as to how far it suffices to meet human needs. This vitamin is normally acquired in two ways—(1) The irradiation of the skin by ultra violet light. (2) Consuming foods containing Vitamin-D. In order for irradiation to be effective, it is first necessary to have present in the skin a pro-vitamin (probably ergosterol). There is as yet no evidence that this pro-vitamin is synthesised in the human body, hence for a healthy life, it is necessary to consume either Vitamin-D or one of its pro-vitamins. Where sunlight is scarce, consumption of Vitamin-D itself is essential. A quart of milk a day supplies about 57-114 units (equivalent to $\frac{1}{6}$ to $\frac{1}{3}$ of a teaspoonful of cod liver oil), which is inadequate for a growing infant. A supplementary supply is therefore necessary, which can take the form of concentrates or Vitamin-D enriched milk. Summer milk is two-and-a-half times as rich in Vitamin-D as winter milk, and this has been shown to be due to the exposure of the cow to sunlight and not to the eating of fresh green grass. The Vitamin-D content can also be augmented by irradiation of milk, but this is comparatively expensive compared with the results obtained. The most effective method of increasing Vitamin-D in milk seems to be to ensure an adequate supply of Vitamin-D in the cow's fodder, as the metabolism of the cow is such that Vitamin-D passes from its food into the milk it is secreting. It is doubtful whether the living matter of the higher plants ever contains Vitamin-D, but various pro-vitamins (sterols) may be present, hence exposure to sunlight after death produces Vitamin-D. Of fodders which owe their Vitamin-D to natural sun-drying, cacao-shell is by far the richest, approaching cod liver oil in potency. It has been shown by feeding trials that, whereas feeding cod liver oil was accompanied by a decrease in the fat percentage of the milk, irradiated yeast (an artifically irradiated supplementary fodder of high Vitamin-D potency) had no effect, while cacao-shell actually caused a slight increase in the fat percentage. This result probably is not due entirely to consumption of Vitamin-D. Cacao-shell is a low priced fodder, which, owing to its theobromine content, is usually fed in amounts of not more than 2 lbs. per day, but this has been shown to be ample to raise the Vitamin-D content of winter milk up to that of summer milk. (A. W. Knapp. *Chemistry and Industry*, 57, pp. 558-561.)

* * *

Soil Organisms and Trace Elements.

That soil organisms may rob higher plants of their necessary minimum of such ions as manganese and zinc is an interpretation that may be made from the investigations of Dr. Gerretsen, Agricultural Experiment Station, Groningen, Netherlands, with the "gray-speck disease" of oats, and of Drs. Ark, Hoagland, Chandler, and Stout, University of California, with "rosette disease" of peach trees. Both diseases can be cured by adding the appropriate element (manganese for oats, and zinc for peach), but in neither case is this addition of nutrient necessary if the soil is merely sterilised, even with such a chemical as formalin which does not increase the soil content either as to manganese or zinc. But such sterilised disease-free soils become again disease-producing if a small quantity (1 to 10 per cent.) of the original non-sterile soil is added, owing to the multiplication of organisms introduced with the non-sterile soil. It appears that the organisms make the manganese or zinc unavailable to the plant, and produce a deficiency disease in a soil containing a sufficiency of the needed element.—(*Ind. Eng. Chem., News Edit.*, Vol. XVI, No. 1, 1938, p. 3.)

* * *

Farmyard Manure in Nigeria.

Earlier experiments to account for the remarkable effect of farmyard manure on Guinea Corn at Zaria were misleading, as, owing to the use of rock phosphate, it was concluded that the effect was not due to the direct value of nitrogen and phosphorus contained in the manure. Since then, the use of a phosphate manure with phosphorus in a readily available form has made it clear that the main limiting factor is a lack of phosphorus, and that the effect of farmyard manure is mainly due to the phosphorus contained in the manure. Experiments with green manures are being continued, and although almost every plant suitable for green manuring known to tropical agriculture has been tried, no entirely successful system of permanent farming by means of green manures has yet been arrived at for the acid sandy soils of the Eastern Provinces of Nigeria. With burning *Mucuna* versus digging it in green there is no appreciable difference in yields of Maize obtained from both sets of plots. There is, however, more organic matter and more total and available nitrogen in the soil of the plots where the *Mucuna* is dug in green, whereas the soil of the other plots is more acid and contains more available mineral nutrients.—(*Imperial Bur. Soil Sci., Soils and Fertilizers*, Vol. I, No. 2, 1938, p. 49.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
29th September ...	5	7½	9	4½
6th October ...	5	3	9	0¾
13th October ...	5	3¾	9	0¾
20th October ...	5	2¼	8	11¼
27th October ...	5	3	8	11¼
3rd November ...	5	6	9	3
10th November ...	5	6	9	6
17th November ...	5	6	9	6¾
(18*th November*, 1937) ...	6	0	8	9¼

Some December liquidation and an absence of demand for actual raws has caused a general sagging tendency which continued till the 25th October when the lowest point in recent weeks was registered, December values touching 5*s.* 0¼*d.* and March 5*s.* 1½*d.* From this point, however, there has been a steady improvement in prices due to a better demand for refined.

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	Pence per lb.
28th September	7 7-8
5th October	8 15-16
12th October	8 3-8
19th October	8 7-16
26th October	8 5-16
2nd November	8 1-4
9th November	8 7-16
16th November	8 1-8
(17*th November*, 1937)	7

The market has been rather dull and inactive with prices moving within narrow limits. Although reports from the American motor industry indicate increased activity, manufacturers are postponing their purchases of rubber in the hope that the Regulations Committee may raise the export quotas for the January quarter. The figure for American consumption at 37,823 tons for the month of September was somewhat disappointing.

* * *

COFFEE.—Interest chiefly has centred in the first arrivals of the new Kenya crop but the quality of most of the coffees was unattractive and demand was slow. Prices were fairly satisfactory, bold sizes realising from 66*s.* to 86*s.*; second sizes 56*s.* to 63*s.* and T.T. 49*s.* 6*d.* to 55*s.* London cleaned Costa Rica is quoted at 67*s.* and Country cleaned medium size 58*s.*, peaberry 73*s.* Superior Santos is 33*s.* 6*d.* and No. 7 Rio 23*s.* 6*d.*, cost and freight.

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian Giza 7.*	*F.G.F. Sakel.*
30th September ...	4.80	7.78	8.13
7th October ...	5.00	7.88	7.98
14th October ...	5.24	8.30	8.30
21st October ...	5.14	8.37	8.47
28th October ...	5.20	8.35	8.35
4th November ...	5.09	—	—
11th November ...	5.05	—	—
18th November ...	5.07	—	—
(19*th Nov.*, 1937)	4.55	7.17	8.20

Although only minor fluctuations have occurred in raw cotton prices, a rather firmer feeling has been prevailing. The third crop estimate by the American Government at 12,212,000 bales was rather larger than expected. West Indian Sea Island has been generally neglected but a few bales at 18*d.* have been sold.

* * *

COCOA.—Since last writing the Gold Coast Commission's Report has been released. In brief, the Commissioners recommend that the buying pool agreement be brought to a conclusion, and the farmers organise themselves into selling groups or associations. It now remains to be seen how this new arrangement will affect the marketing of the West African crop in particular, and the market, in general. New crop Accra is quoted at 21*s.* 6*d.* *c.i.f.* for November-December shipment and $5.60 for Plantation cocoa.—(*The Cocoa Planters' Association of Trinidad, Ltd.*)

* * *

LIME PRODUCTS.—*Lime Oil.*—There is no demand for Handpressed and the nominal value is unchanged at 30*s.* per lb. The market for Distilled is kept weak owing to continued pressure from origin. *Lime Juice.*—There is no inquiry for the inferior grade of Raw, and good quality juice is in slow demand and valued at 2*s.* to 2*s.* 3*d.* with full oil content. There is no demand for Concentrated.—(*West India Committee Circular*, 20th October.)

* * *

COPRA.—The market is again lower and West Indian f.m.s. is quoted at £10 10*s.* c.i.f. nominal, buyers, November shipment.

* * *

BANANAS.—There has been a reduction in demand for Jamaicas which are £1 lower at £18 10*s.* delivered London and £18 5*s.* delivered nearest Station Provinces. Although slow, Brazilians are unchanged at £15 10*s.* delivered London and £16 10*s.* delivered Provinces.

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